IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 2, May 2025 Impact Factor: 7.67

Implementation of a Cost-Effective SCADA System for Micro Industries

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Abstract: *Industrial process automation, monitoring and control depend heavily on SCADA (Supervisory Control and Data Acquisition) systems. An effective and economical SCADA system can make a big difference in operations and production for micro-industries, which typically have limited Dat resources. The simple and inexpensive SCADA for micro industry is the focus of this project. It uses low-end hardware, like PLCs or microcontrollers, in conjunction with an interactive software interface to manage the control process, extract data, and observe in real time. Automation, fault-detection, and remote access are key characteristics that enable the system to save gathered data, improve business decisions, and reduce downtime. It is designed with the latest communication technologies, such as Modbus, and wireless, to ensure it works seamlessly. It is modular and flexible, which allows it to be easily modified to fit any industrial process. Testing shows that it works reliably for real-time operations and stays affordable. This work aims to help small industrial adopt modern technologies, improve efficiency, and stay competitive in today's fast-changing industrial environment.*

Keywords: SCADA System, Industrial automation, Process control, Real-time observation, Remote access, Data acquisition, Wireless communication

I. INTRODUCTION

Supervisory Control and Data Acquisition (SCADA) systems are an integral part of industrial automation, providing real-time monitoring, control, and data acquisition. The system includes embedded controllers (e.g., Arduino or PLCs), sensor modules, communication networks, and SCADA software to support efficient process control. The hardware setup includes a microcontroller unit, relays, sensors, display interfaces, and communications modules, while the software module provides data visualization, remote access, and automatic control. With the integration of a SCADA system into micro-industries, companies can reduce manual intervention, optimize process efficiency, optimize real-time decision-making, and enable predictive maintenance. Additionally, automated alerts and notifications ensure that any fault or anomaly is reported immediately through SMS, notifications, allowing instant action [1]. SCADA also enables real-time control, allowing operators to remotely start or stop machines, adjust process parameters, and debug remotely without physical presence. Additionally, SCADA systems in modern times are integrated with IoT and cloud computing, allowing ease of access, automation, and analysis of data for increased industrial efficiency [3].

SCADA has been conventionally used in large-scale industries, but growing demand for low-cost automation has encouraged the use of SCADA in micro-industries such as small-scale manufacturing, food processing, textiles, and renewable energy industries. SCADA systems are utilized for controlling and observing industrial processes. SCADA systems are specifically effective in micro industries, which are less affluent and need efficient and cost-saving measures. The project aims to close the gap between low-cost automation and high-end industrial control, and SCADA becomes an affordable and scalable option for small-scale enterprises. Micro industries also possess certain inherent issues such as financial constraints, lack of good technical expertise, and the need for systems that can scale up with their business [2]. SCADA implementation assists in overcoming these issues via process automation, cost of operations reduction, minimization of errors, and real-time monitoring. This article sets forth the SCADA system

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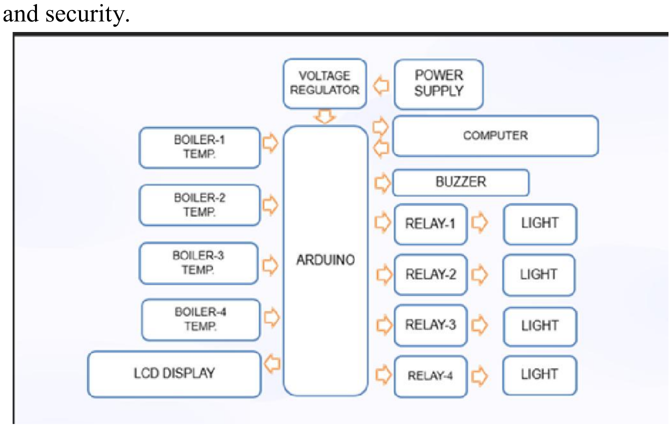

Figure 1. Block Diagram

The received data are then processed and visualized within the SCADA software, wherein the data gets processed and output to Human-Machine Interfaces (HMIs) as graphs, alarms, and dashboards. The operators then act on this information. Lastly, based on processed information, decision-making and control functions allow SCADA to activate alarms, drive actuators, and adjust operating parameters as required to provide efficiency and safety.

II. METHODOLOGY

SCADA systems are crucial to micro-industries as they allow real-time collection of data, monitoring, and control of industrial processes. The SCADA system integrates data from different sensors and field devices monitoring critical parameters such as temperature and equipment performance [4]. The integrated data is monitored round the clock for efficiency in operation and to prevent potential breakdowns. to prevent possible failures and ensure efficient operations. Remote Terminal Units (RTUs) and Programmable Logic Controllers (PLCs) are employed to convey this sensor

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information to the central SCADA system. RTUs act as buffers between the sensors and the central system, with data collection and communication, and PLCs carry out automatic control actions through pre-programmed logic. For instance, if a temperature sensor detects excess heat from a machine, the PLC can trigger an auto-shutdown or activate a cooling system to prevent damage [5,6].

Upon receipt, the SCADA software displays and processes the information using a simple User Interface (UI), which provides real-time dashboards, graphical displays, and alert message, alarm notification. These enable easy monitoring of Key Performance Indicators (KPIs), supporting proactive decision-making without the intervention of human operators. In case a parameter exceeds the specified limit, SCADA triggers automatic responses such as powering down equipment to prevent overheating, setting adjustments to ensure safe working conditions, or diverting material flow for improved production. These automated responses ensure safety, operational efficiency, and downtime reduction in micro-industries [8]. Other than real-time monitoring and control, SCADA systems store their historical data for further analysis and reporting.

As a result, industries follow the machine's performance, optimize energy consumption, and ensure safety and quality compliance. Cloud-based storage is a large part of what has become the hallmark of many modern SCADA solutions for scalability and remote accessibility.

SCADA systems are widely used in various micro-industries to optimize different processes. In a small-scale manufacturing environment, SCADA helps operation such as the metalwork, plastic melding, and assembly lines by controlling and monitoring a machine's health in the production process. SCADA optimization can help the food processing industry maintain consistent temperature and humidity levels in storage units to guarantee food safety and quality. In the textile industry, SCADA controls dyeing and drying processes for enhanced quality and efficiency of the fabrics. The renewable energy sector-which comprises micro-grids in solar and wind energy-reliably utilizes SCADA to track real-time performance and optimize systems. Moreover, water treatment plants rely on SCADA for the automated pumping, filtration, and quality control processes to efficiently manage resources.

Figure 4: System Hardware

2.1 Hardware Component

2.1.1 Arduino Nano

It is one of the microcontroller boards. It is a microcontroller based on Atmega168 or Atmega328p. It is a very similar board to Arduino Uno board but in pin-configuration and specs, this Nano board has come in place of Arduino Uno because it is smaller in size. We know that in an embedded system design small-sized devices are used. It can be designed using a microcontroller such as Atmega328. This microcontroller is also employed in Arduino Uno. It is a compact size board and very adaptable with plenty of various applications. It has no DC jack so that the power supply is provided via a small USB connector otherwise directly connected with the pins like VCC & GND. This board can be powered with 6 to 20 volts via a mini-USB port on the board.

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2.1.2 Temperature Sensor

One such temperature sensor is the DS1820, and it gives 9- to 12-bit temperature readings. These are numerical values of the device's temperature. This sensor can be connected to an internal CPU through a one-wire bus protocol, wherein a single data line is employed. Additionally, this sensor obtains power directly from the data line, rendering an external power source unnecessary. DS1820 temperature sensor is applied in a few fields such as thermostatic controls, domestic appliances, industrial control systems, and temperature-sensitive systems. The sensor can be acquired in two forms such as regular DS18B20 sensor and water-resistant DS18B20 sensor and are applied in hydro-projects to compute the water temperature [5,6].

2.1.3 16x2 Display

LCD stands for liquid crystal display. LCD is one such type of electronic display module that is used in enormous quantities of diverse applications like diversified circuits & devices such as cell phones, calculators, PCs, TVs, etc. All such type of display is highly preferred to use with multi-segment light-emitting diodes and seven segments. The largest advantages in this module's application are economical; easily programmable, animations, no display special & even animation constraints, personalized characters, etc.

2.1.4 Voltage Regulator

A voltage regulator is a device that helps keep the voltage in a power supply steady and safe. It protects electronics from voltage spikes or drops, making sure everything runs smoothly even during power outages or when the load changes. It works with both AC and DC power, and you'll often find it in vehicles, where it keeps the generator's output in check to match what the car's electrical system and battery need.

2.1.5 Relay

A relay is fundamentally an automatic switch that uses electricity to open or close circuits. In EV charging stations, relays assist with handling the power flow to the vehicle and have a large part in ensuring that things are safe—such as turning off power if there is a ground fault. The primary relay is operated by the internal system of the car and only activates when all appears well. When it is safe to do so, the relay initiates the charging. And if you unplug the cord, the relay turns off to avoid sparks or damage where the plug connects.

III. RESULT AND DISCUSSION

SCADA systems contribute significantly to micro-industries by supporting real-time data gathering, monitoring, and automated process control within industries. Smooth data transmission is supported by sensors, RTUs, and PLCs, while automatic responses to critical events lower operation costs and improve safety. The user-friendly interface simplifies KPI management for operators, while data storage in history enables analysis of performance and compliance. By minimizing downtime, optimizing the utilization of resources, and minimizing human hand intervention, SCADA systems enhance productivity, reliability, and scalability for micro-industries.

IV. CONCLUSION

The inclusion of a SCADA system in a micro-industry makes it more efficient, reduces costs, and improves reliability in the system. Real-time monitoring and automation are realized if industries thoroughly analyse industrial requirements and select compatible hardware and software as well as ensuring integration ease with sensors and PLCs. Optimal performance with security is also provided through rigorous testing. Its performance and life span improve with ongoing training of the operators and maintenance of the system. On the whole, an effective SCADA deployment will offer industrial process control, reduce downtime, and provide scalable growth to micro-industries. Planning and deploying SCADA system for micro industries requires detailed attention to hardware, software, communication protocols, and cybersecurity. By emphasizing cost-efficient solutions and adhering to proper installation, configuration, and training, micro industries can utilize SCADA systems to increase their operational reliability and efficiency. The deployment process should entail a systematic project management methodology with clearly defined timelines and resource utilization. In spite of the difficulties presented by budgetary limitations and security threats, a SCADA system properly designed and implemented can bring many advantages, such as lowered operating expenses, better process control, better data gathering, and higher productivity. All these reasons make SCADA systems a valuable investment

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for micro industries that seek to upgrade their operations and keep up with the growing trend towards automation in the industrial sector.

REFERENCES

[1] K. Sharma, A. Singh, and M. Kumar, "IoT-Enabled SCADA Systems for Smart Manufacturing: A Review," Journal of Industrial Internet of Things, vol. 7, no. 3, pp. 124–137, 2020.
This study explores the integration of IoT in SCADA systems, focusing on its applications in smart manufacturing and cost-effective automation solutions.
[2] J. Zhao, L. Zhou, and X. Li, "Wireless SCADA System Design for Remote Industrial Control Applications," IEEE Access, vol. 9, pp. 78456–78465, 2021.
This paper discusses the development of wireless SCADA systems for remote industrial operations, emphasizing low-cost and scalable solutions.
[3] R. Agrawal and P. Banerjee, "A Comprehensive Framework for SCADA Systems in Energy Management," International Journal of Energy Systems Engineering, vol. 12, no. 1, pp. 18–27, 2019.
Focused on energy management, this paper reviews the use of SCADA systems for real time monitoring and efficient control of industrial processes.
[4] M. Alshahrani and T. Alameri, "Enhancing SCADA Systems with ZigBee Technology for Temperature Monitoring," Arabian Journal of Engineering and Sciences, vol. 5, pp. 132–141, 2022.
This research highlights the application of ZigBee technology in SCADA systems for accurate and real- time temperature control in industrial setups.
[5] C. Gupta and H. Patel, "Automation in Micro-Industries: SCADA-Based Temperature Control Systems," Journal of Micro-Industry Automation, vol. 4, no. 2, pp. 89–96, 2023.
This paper presents the implementation of SCADA systems for improving operational efficiency in micro-industries through automated temperature control.
[6] B. K. Singh and A. Das, "Arduino-Based Temperature Monitoring and Control Using SCADA," International Journal of Embedded Systems and Control Engineering, vol. 10, no. 1, pp. 45–56, 2020.
A practical approach to designing an Arduino-based SCADA system for precise temperature monitoring and control in small-scale industries.
[7] D. Roy and S. Khan, "Integration of Wireless Technologies in SCADA Systems for Industrial Automation," Automation and Robotics Today, vol. 14, no. 3, pp. 98–105, 2021.
This article examines the role of wireless communication technologies, such as ZigBee and Bluetooth, in modern SCADA systems for industrial applications.
[8] Y. Zhang, X. Sun, and M. Chen, "Secure Data Transmission in SCADA Systems: Challenges and Solutions," Cybersecurity in Automation, vol. 8, pp. 56–68, 2022.
A comprehensive overview of security issues and mitigation strategies for data transmission in SCADA systems.